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(54) **FUEL SUPPLY STRUCTURE IN VEHICLE ENGINE**

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F02M 35/04	(2006.01)
F02M 35/16	(2006.01)
F02B 61/02	(2006.01)

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USPC 123/431, 445, 468, 470; 180/219

See application file for complete search history.

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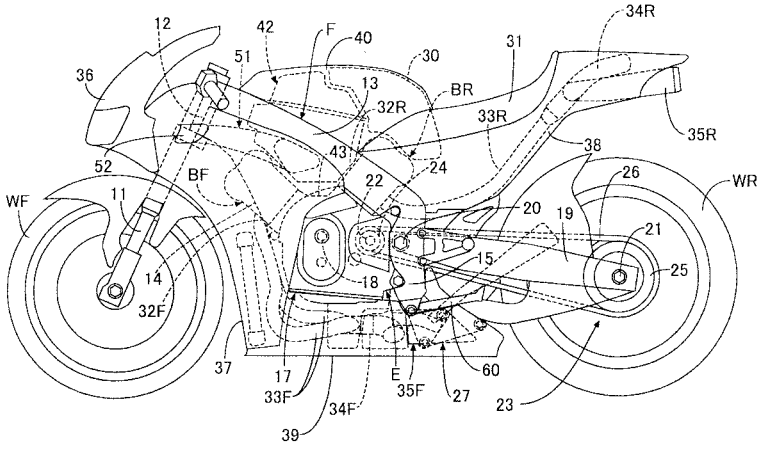
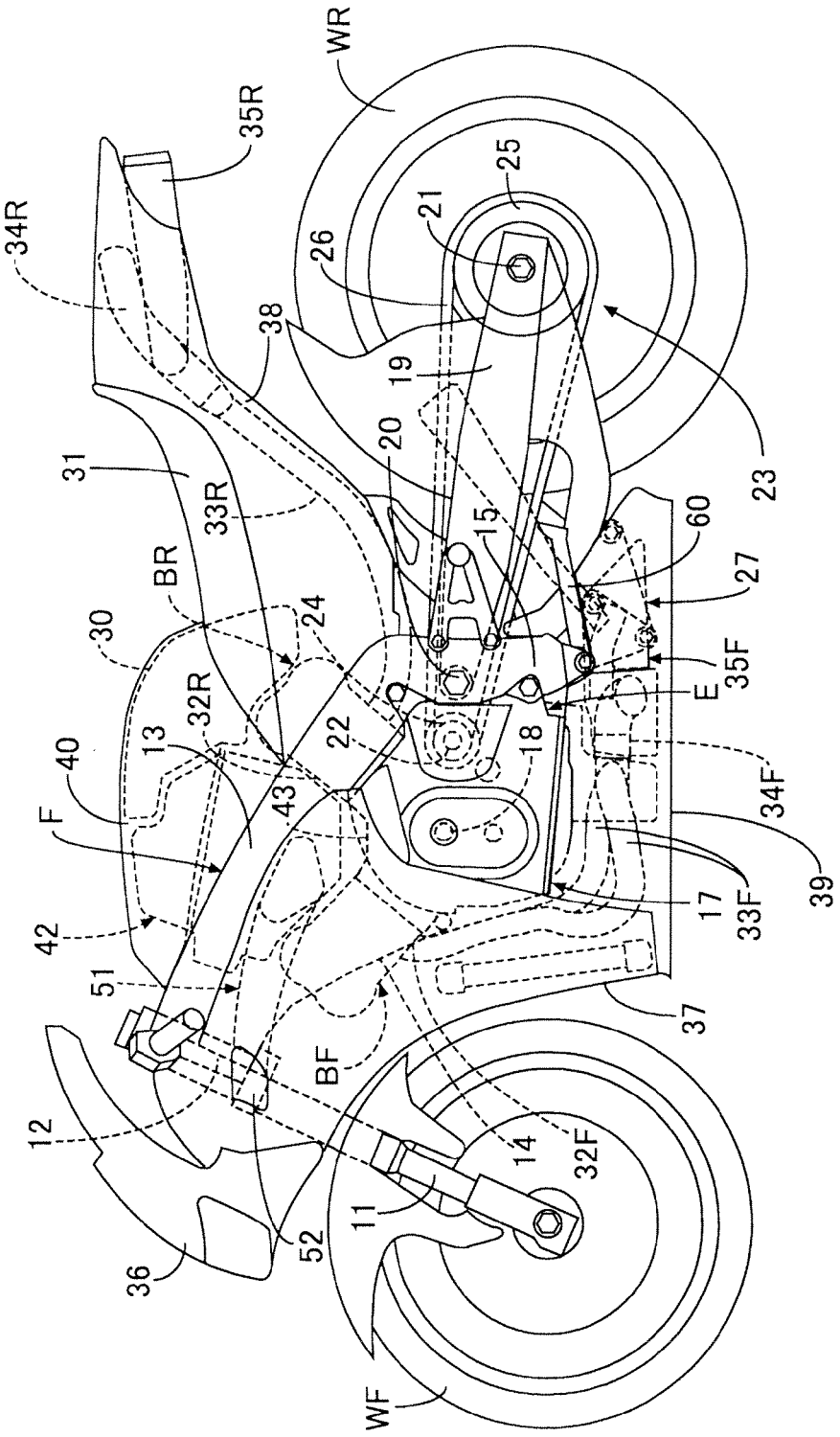
(57) **ABSTRACT**

A main fuel injection valve and a secondary fuel injection valve are separately housed in a purified chamber and an unpurified chamber of an air cleaner. A common fuel supply conduit for leading fuel from a fuel tank is connected to a branching connection pipe which is supported to pass through a cleaner case and a bulkhead and which is placed in one of the unpurified chamber and the purified chamber **49**. The branching connection pipe is connected to a main fuel injection valve side branched fuel conduit and a secondary fuel injection valve side branched fuel conduit.

18 Claims, 5 Drawing Sheets

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22
18
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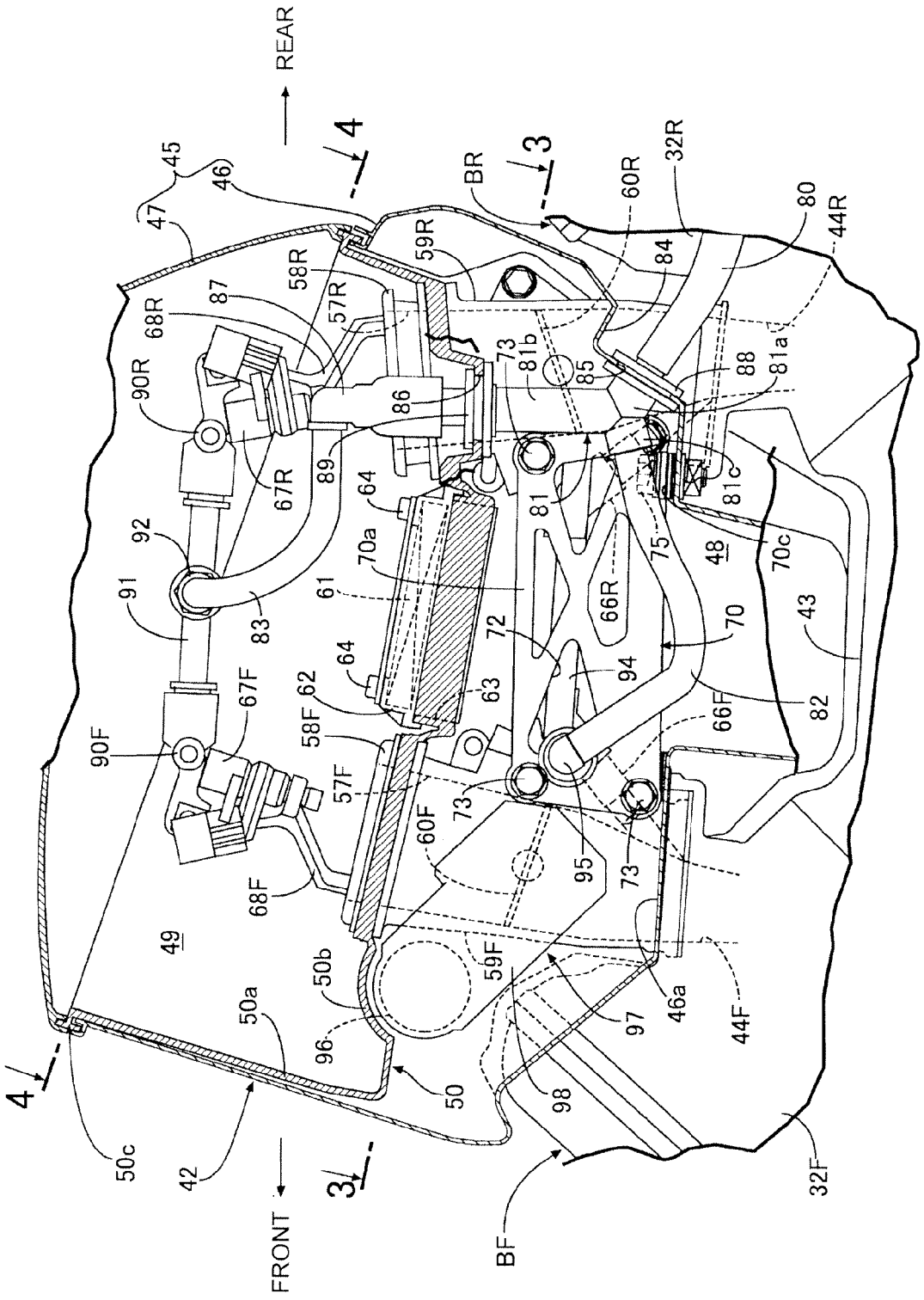
WF

FIG. 1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86
64
70a
61
83
91
92
72
63
62
58F
67F
90F
57F
60F
68F
49
50b
50a
96
50
50c
42
59F
97
98
95
73
81b
85
84
60R
32R
80
44R
88
81a
81c
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48
70c
66R
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43
94
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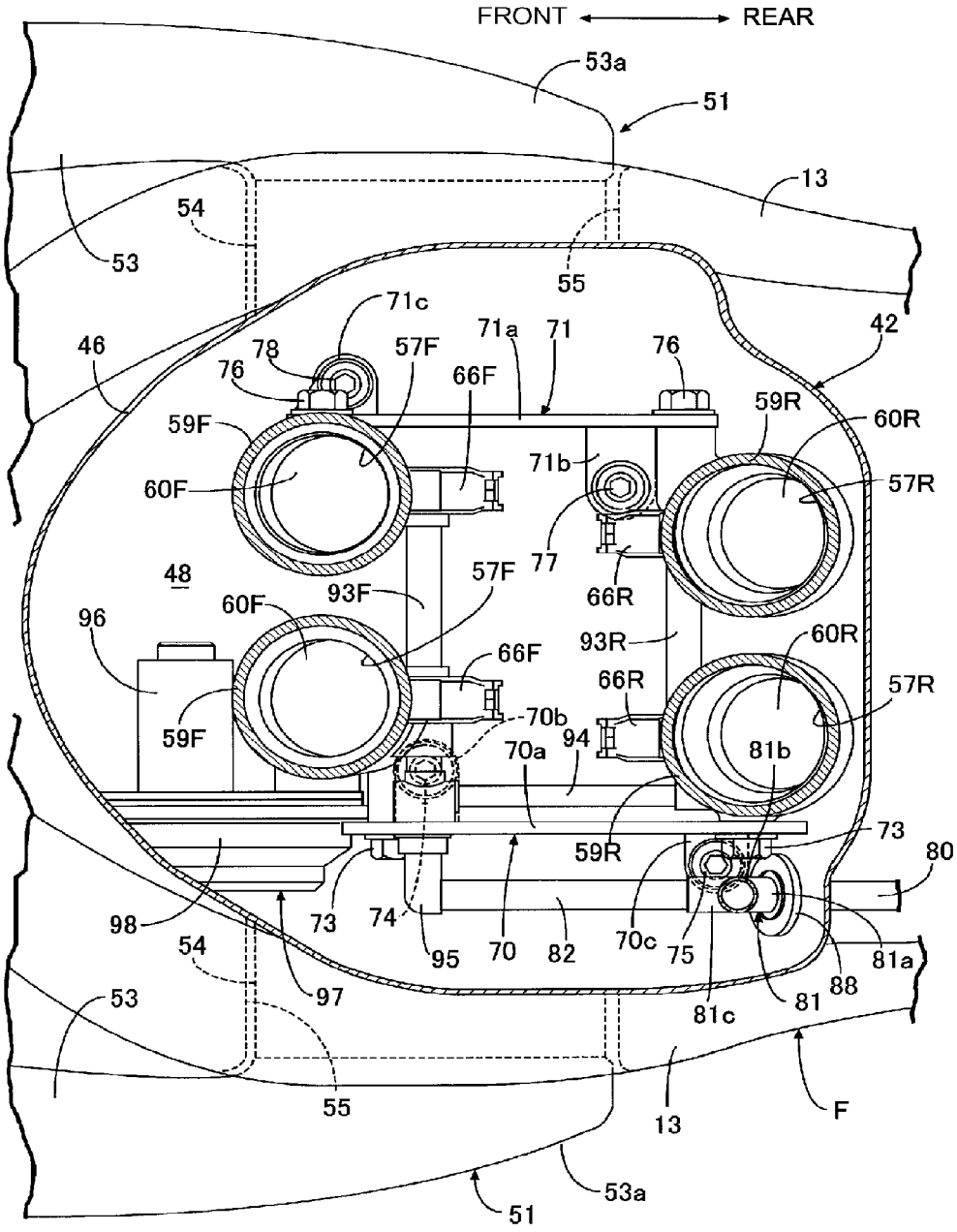
46a
44F
32F

FIG. 2

FIG. 3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57F
60F
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93R
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66F
66R
57R
70b
59F
70a
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81b
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80
59R
98
73
74
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81a
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95
97
88
53
81
81c
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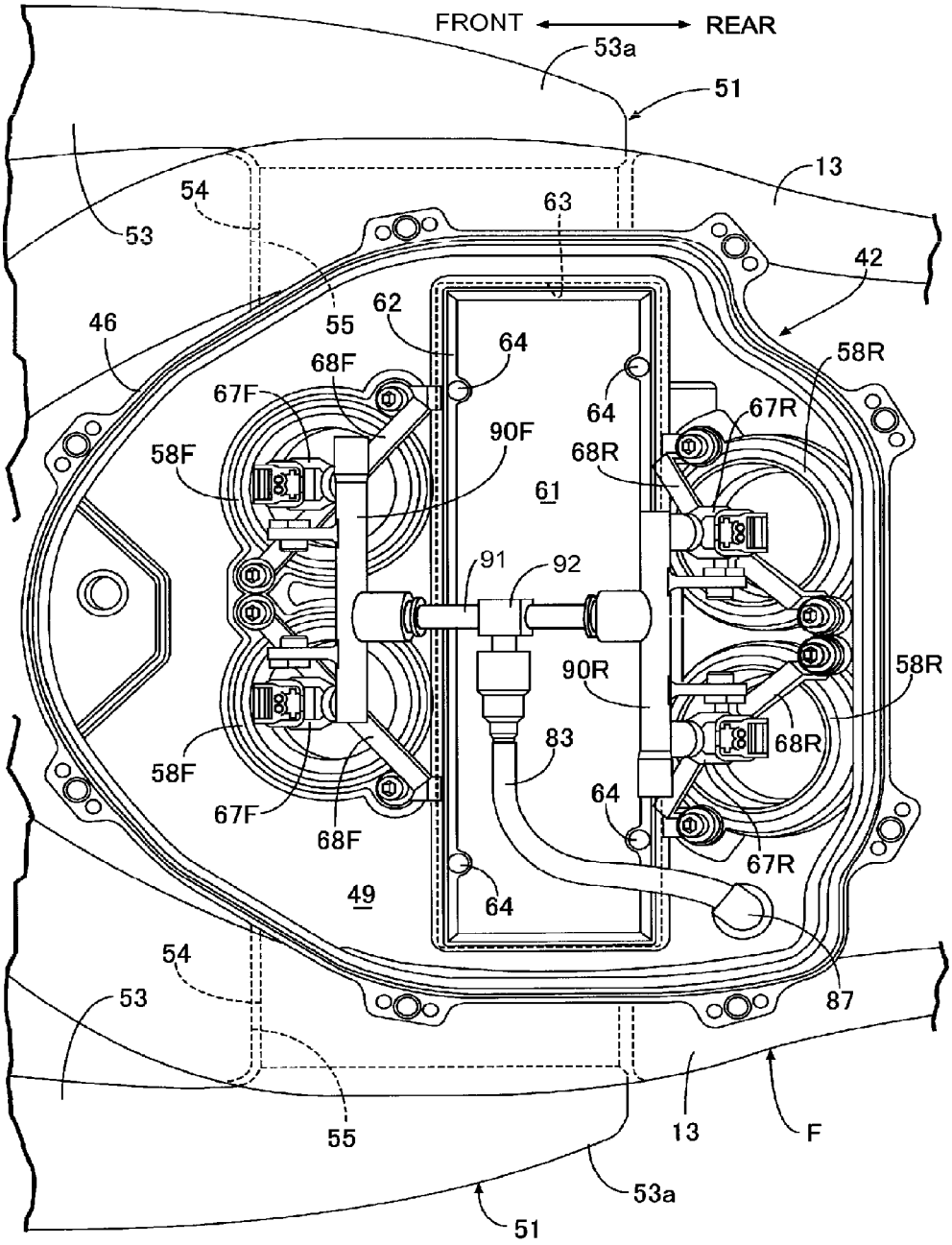
13
F
53a
51

FIG. 4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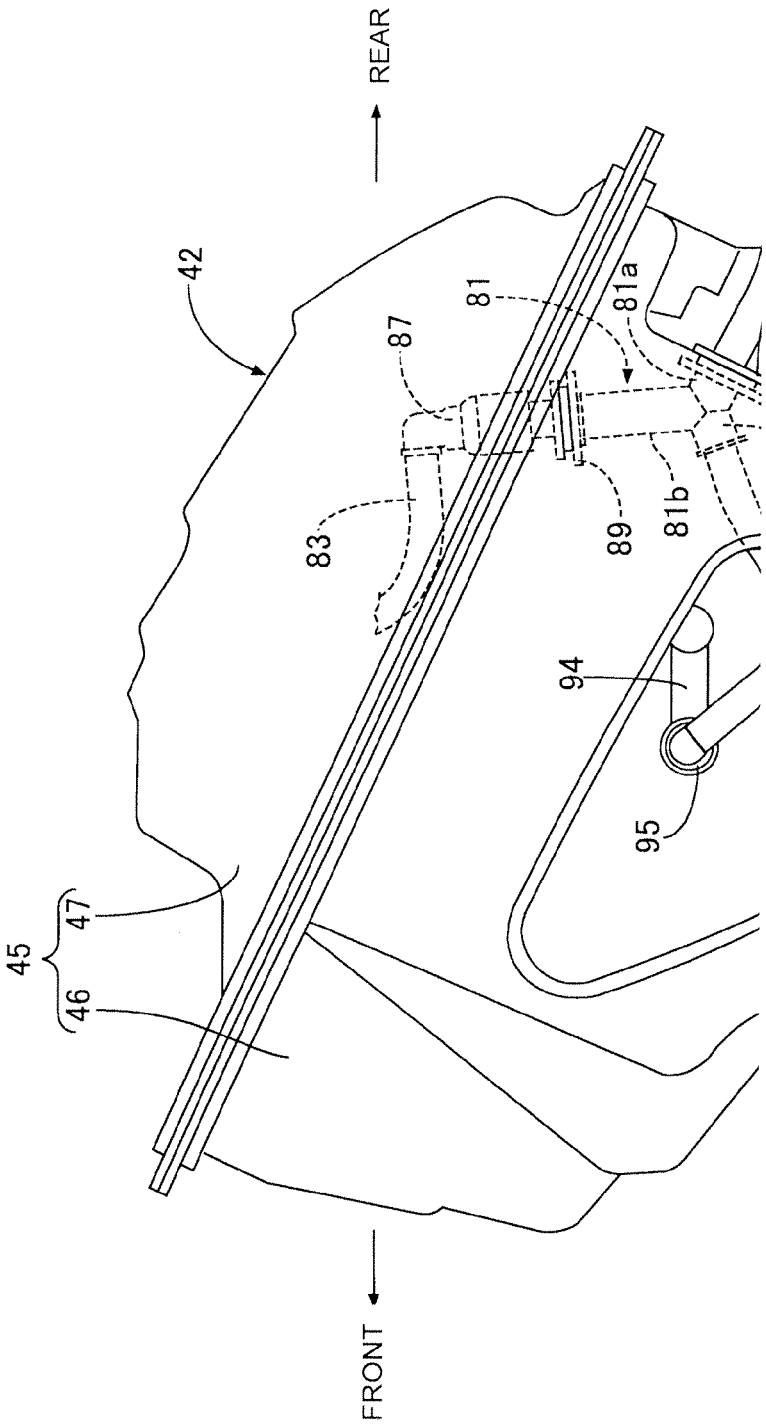

FIG. 5

FUEL SUPPLY STRUCTURE IN VEHICLE ENGINE

BACKGROUND

Field

The present invention relates to a vehicle engine which is provided with an air cleaner of the configuration that the interior of a cleaner case is divided into an unpurified chamber and a purified chamber by a bulkhead holding a cleaner element, a main fuel injection valve for injecting fuel into an intake passage that makes communication between an intake port provided in a cylinder head of an engine body and the purified chamber, and a secondary fuel injection valve for injecting fuel into the intake passage along a flow direction in the intake passage on an upper side in stream than the main fuel injection valve, and particularly, to an improvement in a fuel supply structure.

Description of the Related Art

As disclosed in JP Patent No. 4598838 (patent literature 1), there has already been known a vehicle engine in which fuel is enabled to be injected into an intake passage making communication between a purified chamber of an air cleaner and an intake port in a cylinder head, from a main fuel injection valve on a downstream side in a flow direction in the intake passage and from a secondary fuel injection valve on an upstream side in the flow direction.

In patent literature 1, a main fuel injection valve is attached to a throttle body arranged outside the air cleaner, while the secondary fuel injection valve is housed in the air cleaner or attached to the air cleaner from the outside of the same, to reduce restrictions on the freedom in piping fuel pipes to the main fuel injection valve and the secondary fuel injection valve. However, where the air cleaner is configured to be large in order to accommodate required capacity, the main fuel injection valve and the secondary fuel injection valve are housed together with the throttle body and the like in the air cleaner. This can help avoid a dimensional increase of an intake device that would result from securing, outside the air cleaner, the space required to arrange parts forming the air passage such as the throttle body and the like, the main fuel injection valve and the secondary fuel injection valve. In this case, it is desirable that the fuel piping for supplying fuel to the main fuel injection valve and the secondary fuel injection valve be of the structure which decrease the number of required parts, and which can be arranged in an air cleaner having a spatial restriction.

SUMMARY

The present invention has been achieved in view of the above-mentioned circumstances, and an object of the present invention is to provide a fuel supply structure in a vehicle engine wherein fuel piping to a main fuel injection valve and a secondary fuel injection valve that are housed in an air cleaner can be arranged in a simplified structure having parts decreased in number.

To attain the above-mentioned object, a vehicle engine can be provided with an air cleaner configured to be divided in a cleaner case by a bulkhead holding a cleaner element into an unpurified chamber and a purified chamber. A main fuel injection valve is provided, for injecting fuel into an intake passage that makes communication between an intake port provided on a cylinder head in an engine body and the purified chamber. A secondary fuel injection valve is provided, for injecting fuel into the intake passage on an upper side in stream than the main fuel injection valve in a flow direction in the intake passage. A first feature of the invention resides in that one of the main fuel injection valve and the secondary fuel injection valve is housed in the purified chamber. The other of the main fuel injection valve and the secondary fuel injection valve is housed in the unpurified chamber. A common fuel supply conduit for leading fuel from a fuel tank to the main fuel injection valve and the secondary fuel injection valve in common is connected to a branching connection pipe which is supported to pass through the cleaner case and the bulkhead and which is placed in one of the unpurified chamber and the purified chamber. The branching connection pipe is connected to a main fuel injection valve side branched fuel conduit for leading fuel toward the main fuel injection valve side and to a secondary fuel injection valve side branched fuel conduit for leading fuel toward the secondary fuel injection valve side.

A second feature of the invention resides in that the branching connection pipe having a pair of branched pipe portions is placed in the unpurified chamber and that one of both of the branched pipe portions passes through the bulkhead and is supported by the bulkhead to open on the purified chamber side.

A third feature of the invention resides in that a lower case half body and an upper case half body are dividable vertically and are combined to constitute the cleaner case, and the branching connection pipe which is arranged in the unpurified chamber defined between the bulkhead and the lower case half body passes through the lower case half body, and is connected to the common fuel supply conduit.

A fourth feature of the invention resides in that the branched pipe portion on one side possessed by the branching connection pipe and opening on the purified chamber side is connected by a quick connector to the branched fuel conduit which, of the main fuel injection valve side branched fuel conduit and the secondary fuel injection valve side branched fuel conduit, is arranged in the purified chamber.

A fifth feature of the invention resides in that annular elastic seal members are respectively interposed between the branching connection pipe, and the cleaner case and the bulkhead.

A sixth feature of the invention resides in that at least a part of the intake passage making communication between the purified chamber and the intake port is formed by an air funnel opening to the purified chamber and a throttle body arranged in the unpurified chamber and connected to a downstream end part of the air funnel.

A seventh feature of the invention resides in that the throttle bodies separated in a vehicle front-rear direction are arranged in the unpurified chamber with themselves mutually coupled by a bracket arranged on a lateral side of the throttle bodies. A joint member connects the main fuel injection valve side branched fuel conduit to a main fuel injection valve side fuel supply pipe, and is connected to the main fuel injection valves respectively annexed to the throttle bodies is arranged to pass through the bracket.

An eighth feature of the invention resides in that the bracket has a connecting plate portion which is fastened to the throttle bodies separated in the vehicle front-rear direction and which is provided with a perforated aperture making the joint member pass therethrough. A first boss portion is arranged on the throttle bodies side with respect to the connecting plate portion and is consecutively connected to either one of front and rear parts of the connecting plate portion to be fastened to a lower part of the cleaner case. A second boss portion is arranged on an opposite side to the

throttle bodies with respect to the connecting plate portion and is consecutively connected to the other of the front and rear parts of the connecting plate portion to be fastened to a lower part of the cleaner case. The joint member and the first boss portion are arranged to overlap partly at least as viewed in a plan view.

A ninth feature of the invention resides in that the branching connection pipe is placed at such a position where, as viewed laterally, it overlaps a part of the the throttle body on a rear side of the throttle bodies separated in the vehicle front-rear direction. An electric motor is provided, for generating a power to drivingly turn throttle valves respectively provided in the throttle bodies, and is housed in the unpurified chamber to be placed ahead of the throttle body on a front side of the throttle bodies separated in the vehicle front-rear direction.

According to the first feature of the present invention, the main fuel injection valve and the secondary fuel injection valve are separately housed in the purified chamber and the unpurified chamber of the air cleaner. The common fuel supply conduit is in common to the main fuel injection valve, and the secondary fuel injection valve is connected to the branching connection pipe which is placed in one of the unpurified chamber and the purified chamber and which is supported to pass through the cleaner case and the bulkhead. The branching connection pipe is connected to the main fuel injection valve side branched fuel conduit and the secondary fuel injection valve side branched fuel conduit. Thus, the fuel piping can be simplified by containing in the air cleaner the branching connection pipe that distributes fuel to the main fuel injection valve and the secondary fuel injection valve. A decrease in the number of parts can be realized by making unnecessary fastening members or the like that secure the branching connection pipe to the cleaner case. Also, performing machining to form fastening portions on the cleaner case and the branching connection pipe becomes unnecessary, whereby the manpower and cost of machining can be decreased.

Further, according to the second feature of the present invention, one of the paired branched pipe portions which the branching connection pipe placed in the unpurified chamber passes through the bulkhead and is supported by the bulkhead to open on the purified chamber side. Thus, it is unnecessary to perform the machining for the fuel piping connection at a part on the purified chamber side of the cleaner case, and this contributes to securing the airtightness of the purified chamber.

According to the third feature of the present invention, since the branching connection pipe placed in the unpurified chamber passes through the lower case half body that constitutes the cleaner case in cooperation with the upper case half body and that defines the unpurified chamber between itself and the bulkhead, it is unnecessary to perform machining for fuel piping connection at a part on the purified chamber side of the cleaner case. This contributes to securing the airtightness of the purified chamber.

According to the fourth feature of the present invention, the branched pipe portion which, of the pair of branched pipe portions possessed by the branching connection pipe, opens on the purified chamber side is connected by the quick connector to the branched fuel conduit which, of the main fuel injection valve side branched fuel conduit and the secondary fuel injection valve side branched fuel conduit, is disposed in the purified chamber. Thus, at the time of assembling the air cleaner, a tool is not required in connecting the branched pipe portion opening on the purified chamber side to the branched fuel conduit placed in the purified chamber, so that the interior of the purified chamber can be prevented from becoming dirty.

According to the fifth feature of the present invention, since the branching connection pipe is supported by the cleaner case and the bulkhead through the annular elastic seal members, the sealing performance at the portions where the branching connection pipe passes through can be ensured. Furthermore, the pulsation in fuel pressure can be prevented from being transmitted from the branching connection pipe to the cleaner case, so that the generation of vibration at the cleaner case can be suppressed.

According to the sixth feature of the present invention, since the throttle body constituting at least a part of the intake passage is disposed in the unpurified chamber, a required capacity of the air cleaner can be secured by arranging in the unpurified chamber movable members such as the throttle valve urged in the throttle bodies. This contributes to downsizing the whole of the intake device extending from the air cleaner to the cylinder head.

According to the seventh feature of the present invention, the joint member which connects the main fuel injection valve side fuel supply pipe and the main fuel injection valve side branched fuel conduit passes through the bracket mutually coupling the throttle bodies separated in the front-rear direction. The main fuel injection valve side fuel supply pipe is connected to main fuel injection valves respectively annexed to the throttle bodies. This makes it easy to perform the connection and separation between the main fuel injection valve side fuel supply pipe and the main fuel injection valve side branched fuel conduit at the time of assembling and disassembling, and hence, contributes to simplifying the fuel piping.

According to the eighth feature of the present invention, the first boss portion, constituting a part of the bracket and fastened to the lower part of the cleaner case by a fastening operation from under the cleaner case, and the joint member are arranged to overlap each other partly at least as viewed in the plan view. Thus, the region occupied by the first boss portion and the region occupied by the joint member are piled up vertically. This makes it possible to avoid an increase in dimension of the cleaner case and at the same time, to secure the space required for performing the fastening operation of the first boss portion to the cleaner case.

According to the ninth feature of the present invention, the branching connection pipe, as viewed in the lateral direction, overlaps a part of the throttle body on the rear side of the throttle bodies separated in the front-rear direction. The electric motor for generating the power to drivingly turn the throttle valves is located ahead of the throttle body on the front side of the throttle bodies separated in the front-rear direction. Thus, it can be avoided that the air cleaner housing the fuel supply device increases in dimension.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a left side view of a motorcycle.

FIG. **2** is a longitudinal sectional view of an essential part of an engine.

FIG. **3** is a sectional view taken along line **3-3** in FIG. **2**.

FIG. **4** is a view from an arrow direction, taken along line **4-4** in FIG. **2** in the state that an upper case half body is omitted.

FIG. **5** is a side view of an air cleaner as viewed in the same direction as in FIG. **2**.

DETAILED DESCRIPTION

Embodiments according to the present invention will be described with reference to the accompanying drawings. It

is to be noted that, throughout the following description, front-rear, upward-downward and right-left will be referred to as those directions viewed by a rider of a motorcycle.

In FIG. **1**, a body frame F of a motorcycle being a saddle-ride type vehicle is provided with a head pipe **12** steerably supporting a front fork **11** to which a front wheel WF is journaled. A pair of right and left main frames **13** extend downward toward the rear from the head pipe **12**, and a pair of right and left engine hangers **14** are welded to the head pipe **12** and front parts of both the main frames **13** and extending downward from the main frames **13**. A pair of right and left pivot frames **15** extend downward from the rear parts of the main frames **13**.

The body frame F is equipped with an engine body **17** of, for example, a V-type engine E constituted by four cylinders. In this embodiment, the engine body **17** is supported by lower parts of the pair of engine hangers **14**, intermediate parts of the main frames **13** and upper parts and lower parts of the pair of pivot frames **15** so that a crankshaft **18** extending in a vehicle width direction is rotatably supported. The engine body **17** has a front bank BF and a rear bank BR arranged to take a V-shape. Each bank has two cylinders aligned in an axial direction of the crankshaft **18**.

Vertically intermediate parts of the pair of pivot frames **15** swingably support a front end part of a swing arm **19** through a spindle **20**. An axle **21** for a rear wheel WR is rotatably supported to a rear end part of the swing arm **19**.

Power from an output shaft **22** of a transmission incorporated in the engine body **17** is transmitted to the rear wheel WR through chain transmission means **23**. Chain transmission means **23** is composed of a drive sprocket **24** fixed on the output shaft **22**, a driven sprocket **25** fixed on the axle **21** for the rear wheel WR, and an endless chain **26** wound around these sprockets **24**, **25**.

A front part of the swing arm **19** is coupled to lower parts of the pair of pivot frames **15** through a link mechanism **27**. A rear cushion unit (not shown) is provided between a member constituting a part of the link mechanism **27** and the rear parts of the main frames **13**.

Over the rear bank BR in the engine body **17**, a fuel tank **30** is supported by the main frames **13**. Riding seat **31** is arranged behind the fuel tank **30**, and is supported at the rear parts of the body frames F.

A pair of front bank side discrete exhaust pipes **33**F that communicate on a cylinder-by-cylinder basis with cylinder heads **32**F of the front bank BF in the engine body **17** is extended rearward through under the engine body **17** and is connected in common to a front bank side exhaust manifold **34**F. The front bank side exhaust manifold **34**F is connected to a front bank side exhaust muffler **35**F arranged behind and under the engine body **17**. A pair of rear bank side discrete exhaust pipes **33**R that communicate on a cylinder-by-cylinder basis with cylinder heads **32**R of the rear bank BR in the engine body **17** and that extend rearward is connected to a rear bank side exhaust manifold **34**R behind the riding seat **31**. The rear bank side exhaust manifold **34**R is connected to a rear bank side exhaust muffler **35**R arranged over the rear wheel WR.

The head pipe **12** in the body frame F is covered by a front cowl **36** from the front side thereof. The front part of the body frame F and a part of the engine body **17** are covered by a pair of right and left center cowls **37** from the lateral sides. The rear part of the body frame F, the rear bank side discrete exhaust pipes **33**R, the rear bank side exhaust manifold **34**R, and the rear bank side exhaust muffler **35**R are covered by a rear cowl **38** so that a rear part of the rear bank side exhaust muffler **35**R protrudes rearward. Further, a part of the front bank side discrete exhaust pipes **33**F, the front bank side exhaust manifold **34**F, and the front bank side exhaust muffler **35**F are covered by an under cowl **39** whose front end part is consecutively connected to a lower part of the center cowl **37**, from the lower side and both the lateral sides.

Over the engine body **17** and ahead of the fuel tank **30**, a single air cleaner **42** common to the front bank BF and the rear bank BR is arranged so as to be partly received in a hollow **43** between the front bank BF and the rear bank BR and to be put between the pair of right and left main frames **13** constituting a part of the body frame F, and the air cleaner **42**, together with fuel tank **30**, is covered by a cover **40**.

Also referring to FIG. **2**, in sidewalls of the cylinder heads **32**F, **32**R, facing the hollow **43** between the front and rear banks BF, BR of the engine body **17**, intake ports **44**F, **44**R discretely corresponding to two pair of cylinders are provided to extend vertically.

A cleaner case **45** of the air cleaner **42** is constructed by mutually combining a lower case half body **46** and an upper case half body **47** which are dividable in the vertical direction. The upper case half body **47** is combined with an upper end part of the lower case half body **46** so as to close an upper end opening of the lower case half body **46** that is formed like an upward opening box. A bulkhead **50** dividing the interior of the cleaner case **45** into a lower unpurified chamber **48** and an upper purified chamber **49** is put between the lower case half body **46** and the upper case half body **47**.

The bulkhead **50** integrally has a cylindrical sidewall portion **50***a* that, from inside, comes close to and faces an internal surface of an upper sidewall in the lower case half body **46** of the cleaner case **45**. A bottom board portion **50***b* consecutively connected to a lower end of the sidewall portion **50***a*, and a sandwiched portion **50***c* taking an almost T-shape in cross-section and protruding outward from an upper end of the sidewall portion **50***a*. The sandwiched portion **50***c* is put between the upper end portion of the lower case half body **46** and the lower end portion of the upper case half body **47**.

Also referring to FIG. **3** and FIG. **4**, outside air lead means for leading the outside air to the unpurified chamber **48** are connected respectively to both side portions in the vehicle width direction of the lower case half body **46** in the cleaner case **45** of the air cleaner **42**.

The outside air lead means **51** are provided with intake ducts **53** that extend in the vehicle front-rear direction to communicate with outside air intake ports **52** (refer to FIG. **1**) provided in front side surfaces of the center cowl **37**. Ducts **53** have bents **53***a* at rear end portions for turning the intake direction from the vehicle front-rear direction to the vehicle width direction. Connecting tubes **54** made of an elastic material make connection between the bents **53***a* and the lower case half body **46**.

Most parts of the intake ducts **53** are arranged to extend in the front-rear direction on the outer sides of the main frames **13**. Upstream end portions of the connecting tubes **54** inserted into through holes **55** that are provided in the main frames **13** in correspondence to the bents **53***a* at the rear end portions of the intake ducts **53** are connected to the bents **53***a*. As shown in FIG. **5**, the lower case half body **46** in the cleaner case **45** of the air cleaner **42** is provided with connection holes **56** at the side portions on both sides in the vehicle width direction. Downstream end portions of the connecting tubes **54** are fitted and connected to the connection holes **56**, so that the outside air led by the outside air lead means **51** is introduced to the unpurified chamber **48** of the air cleaner **42**.

At least some of intake passages **57**F that make communication between the intake ports **44**F for respective cylinders in the cylinder head **32**F of the front bank BF and the purified chamber **49** are formed by air funnels **58**F opening to the purified chamber **49** and throttle bodies **59**F arranged in the unpurified chamber **48** and connected to the downstream end parts of the air funnels **58**F. In this embodiment, the intake passages **57**F are formed by the air funnels **58**F and the throttle bodies **59**F. Further, at least some of intake passages **57**R that make communication between the intake ports **44**R for respective cylinders in the cylinder head **32**R of the rear bank BR and the purified chamber **49** are formed by air funnels **58**R opening to the purified chamber **49** and throttle bodies **59**R arranged in the unpurified chamber **48** and connected to the downstream end parts of the air funnels **58**R. In this embodiment, the intake passages **57**R are formed by the air funnels **58**R and the throttle bodies **59**R.

The throttle bodies **59**F, **59**R pass through the bottom wall **46***a* of the lower case half body **46** to be airtightly connected to the cylinder heads **32**F, **32**R. In addition, the throttle bodies **59**F, **59**R standing connected to the cylinder heads **32**F, **32**R are tilted to come close mutually as they go upward, and throttle valves **60**F, **60**R for controlling the opening degree of the intake passages **57**F, **57**R are pivotably journaled to the throttle bodies **59**F, **59**R.

The air funnels **58**F, **58**R which are so connected as to fit the lower end portions in the upper end portions of the throttle bodies **59**F, **59**R are fitted in the bottom board portion **50***b* of the bulkhead **50** with the upper ends opening to the purified chamber **49**.

In the air cleaner **42**, a cleaner element **61** is located between the throttle bodies **59**F, **59**R separated in the vehicle front-rear direction. The cleaner element **61** takes a rectangular shape and is held in an element support frame **62**. The bottom board portion **50***b* of the bulkhead **50** is provided with a rectangular opening **63** that is long in the vehicle width direction to be arranged between the air funnels **58**F and the throttle bodies **59**F on the front bank BF side and the air funnels **58**R and the throttle bodies **59**R on the rear bank BR side. The element support frame **62** partly fitted in the opening **63** is fastened to the bottom board portion **50***b* of the bulkhead **50** by a plurality of bolts **64** with the cleaner element **61** closing the opening **63**.

That is, the cleaner element **61** takes a rectangular shape and is disposed in the air cleaner **42** between the throttle bodies **59**F on the front bank BF side and the throttle bodies **59**R on the rear bank BR side to be held by the bulkhead **50**, with its longitudinal direction kept in parallel to the axis of the crankshaft **18** extending in the vehicle width direction. Thus, the outside air introduced to the unpurified chamber **48** passes through the cleaner element **61** upward to be led to the purified chamber **49**, and the air purified by the cleaner element **61** turns around downward from the purified chamber **49** to be introduced from the upper ends of the air funnels **58**F, **58**R to the intake ports **44**F, **44**R through the intake passages **57**F, **57**R.

Fuel is injected from main fuel injection valves **66**F, **66**R into the intake passages **57**F, **57**R. On an upper side relative to the main fuel injection valves **66**F, **66**R in the flow direction of the intake passages **57**F, **57**R, fuel is injected from secondary fuel injection valves **67**F, **67**R into the intake passages **57**F, **57**R. One of the main fuel injection valves **66**F, **66**R and the secondary fuel injection valves **67**F, **67**R, (that is, the secondary fuel injection valves **67**F, **67**R in this embodiment) are housed in the purified chamber **49**, while the other of the main fuel injection valves **66**F, **66**R and the secondary fuel injection valves **67**F, **67**R, (that is, the main fuel injection valves **66**F, **66**R in this embodiment) are housed in the unpurified chamber **48** to be attached to the throttle bodies **59**F, **59**F.

The secondary fuel injection valves **67**F on the front bank BF side are supported by valve support frames **68**F which are attached to the bottom board portion **50***b* of the bulkhead **50** to stretch over the air funnels **58**F, and the secondary fuel injection valves **67**R on the rear bank BR side are supported by valve support frames **68**R which are attached to the bottom board portion **50***b* of the bulkhead **50** to stretch over the air funnels **58**R.

The pair of throttle bodies **59**F on the front bank BF side and the pair of throttle bodies **59**R on the rear bank BR side are arranged in the unpurified chamber **48** separately in the vehicle front-rear direction. However, the throttle bodies **59**F, **59**R on the left side in the vehicle width direction are mutually coupled by a left bracket **70** arranged on the left side of these throttle bodies **59**F, **59**R, while the throttle bodies **59**F, **59**R on the right side in the vehicle width direction are mutually coupled by a right bracket **71** arranged on the right side of these throttle bodies **59**F, **59**R.

The bracket **70** on the left side has a connecting plate portion **70***a* that is fastened to the throttle bodies **59**F, **59**R separated in the vehicle front-rear direction on the left side in the vehicle width direction. A first boss portion **70***b* is arranged on the throttle bodies **59**F, **59**R side with respect to the connecting plate portion **70***a* and is consecutively connected to either one of the front and rear parts of the connecting plate portion **70***a* (to the front part in this embodiment) to be fastened to a lower part of the cleaner case **45**. A second boss portion **70***c* is arranged on the opposite side to the throttle bodies **59**F, **59**R with respect to the connecting plate portion **70***a* and is consecutively connected to the other of the front and rear parts of the connecting plate portion **70***a* (to the rear part in this embodiment) to be fastened to a lower part of the cleaner case **45**.

Both of the front and rear end parts of the connecting plate portion **70***a* are fastened by two sets of bolts **73**. Each set includes a pair separated vertically, to the throttle bodies **59**F, **59**R on the left side in the vehicle width direction. Further, the first boss portion **70***b* is fastened by a bolt **74** to the bottom wall **46***a* of the lower case half body **46** in the cleaner case **45**, and the second boss portion **70***c* is fastened by a bolt **75** to the bottom wall **46***a*.

The bracket **71** on the right side has a connecting plate portion **71***a* that is fastened to the throttle bodies **59**F, **59**R separated in the vehicle front-rear direction on the right side in the vehicle width direction. A third boss portion **71***b* is arranged on the throttle bodies **59**F, **59**R side with respect to the connecting plate portion **71***a* and that is consecutively connected to either one of the front and rear parts of the connecting plate portion **71***a* (to the rear part in this embodiment) to be fastened to a lower part of the cleaner case **45**. A fourth boss portion **71***c* is arranged on the opposite side to the throttle bodies **59**F, **59**R with respect to the connecting plate portion **71***a* and is consecutively connected to the other of the front and rear parts of the connecting plate portion **71***a* (to the front part in this embodiment) to be fastened to a lower part of the cleaner case **45**.

Both of the front and rear end parts of the connecting plate portion **71***a* are fastened by two sets of bolts **76**. Each set includes a pair separated vertically, to the throttle bodies **59**F, **59**R on the right side in the vehicle width direction. Further, the third boss portion **71***b* is fastened by a bolt **77** to the bottom wall **46***a* of the lower case half body **46** in the cleaner case **45**, and the fourth boss portion **71***c* is fastened by a bolt **78** to the bottom wall **46***a*.

The connecting plate portion **70***a* of the bracket **70** on the left side is provided with a plurality of perforated apertures **72** as clearly shown in FIG. **2**. The connecting plate portion **71***a* of the bracket **71** on the right side is also provided with a plurality of perforated apertures though the same are not shown in the drawings.

A common fuel supply hose **80** as a common fuel supply conduit for leading fuel from the fuel tank **30** to the main fuel injection valves **66**F, **66**R and the secondary fuel injection valves **67**F, **67**R in common is extended toward the left-rear portion of the lower case half body **46** in the cleaner case **45**. The common fuel supply hose **80** is connected to a branching connection pipe **81** which is supported to pass through the cleaner case **45** and the bulkhead **50** and which is placed in the unpurified chamber **48** being one of the unpurified chamber **48** and the purified chamber **49**. To the branching connection pipe **81**, there are connected a main fuel injection valve side branched fuel hose **82** being a main fuel injection valve side branched fuel conduit for leading fuel toward the main fuel injection valves **66**F, **66**R side, and a secondary fuel injection valve side branched fuel hose **83** being a secondary fuel injection valve side branched fuel conduit for leading fuel toward the secondary fuel injection valves **67**F, **67**R side.

The branching connection pipe **81** takes an almost Y-letter shape having a common pipe portion **81***a* connected to the common fuel supply hose **80** and a pair of branched pipe portions **81***b*, **81***c* branched from the common pipe portion **81***a*. In the branching connection pipe **81** in this embodiment, the common pipe portion **81***a* passes through the lower case half body **46** and is supported to the lower case half body **46** to be disposed in the unpurified chamber **48** on the left side of the connecting plate portion **70***a* of the left bracket **70**. One **81***b* of both of the branched pipe portions **81***b*, **81***c* passes through the bottom board portion **50***b* of the bulkhead **50** and is supported by the bottom board portion **50***b* to open on the purified chamber **49** side.

In addition, the branching connection pipe **81** is placed at such a position where, as viewed laterally, it overlaps some of the throttle bodies **59**R on the rear side of the throttle bodies **59**F and the throttle bodies **59**R separated in the vehicle front-rear direction.

The lower case half body **46** is formed at its left-rear part with a recess **84** opening leftward and rearward. The common pipe portion **81***a* of the branching connection pipe **81** passes through a support hole **85** provided on the lower case half body **46** and is arranged to make its end portion reach the recess **84**. The common fuel supply hose **80** is connected to the end portion of the common pipe portion **81***a* in the recess **84**.

The branched pipe portion **81***b* on one side that the branching connection pipe **81** has to open on the purified chamber **49** side is arranged to pass through a support hole **86** provided in the bottom board portion **50***b* of the bulkhead **50** and to make an end portion open to the purified chamber **49**. The end portion of the branched pipe portion **81***b* is connected by a quick connector **87** to the secondary fuel injection valve side branched fuel hose **83** which, of the main fuel injection valve side branched fuel hose **82** and the secondary fuel injection valve side branched fuel hose **83**, is placed in the purified chamber **49**.

Annular elastic seal members are respectively interposed between the branching connection pipe **81**, and the lower case half body **46** of the cleaner case **45** and the bulkhead **50**. In this embodiment, a grommet **88** as the annular elastic seal member is fitted around the support hole **85** to enable the common pipe portion **81***a* to pass therethrough airtightly, while a grommet **89** as the annular elastic seal member is fitted around the support hole **86** to enable the branched pipe portion **81***b* to pass therethrough airtightly.

Referring now to FIG. **2** and FIG. **4** in particular, a common fuel supply pipe **91** is connected to a fuel supply pipe **90**F that extends in the purified chamber **49** in the vehicle width direction to be connected to the pair of secondary fuel injection valves **67**F aligned in the vehicle width direction on the front bank BF side, and to a fuel supply pipe **90**R that extends in the purified chamber **49** in the vehicle width direction to be connected to the pair of secondary fuel injection valves **67**R aligned in the vehicle width direction on the rear bank BR side. The secondary fuel injection valve side branched fuel hose **83** is connected to a center portion of the common fuel supply pipe **91** through a connecting pipe member **92**.

Referring now to FIG. **3**, between the throttle bodies **59**F aligned in the vehicle width direction on the front bank BF side, there is provided a communication pipe **93**F that extends in the vehicle width direction to make communication of the main fuel injection valves **66**F annexed to the throttle bodies **59**F. Between the throttle bodies **59**R aligned in the vehicle width direction on the rear bank BR side, a communication pipe **93**R extends in the vehicle width direction to make communication of the main fuel injection valves **66**R annexed to the throttle bodies **59**R. Between the throttle bodies **59**F, **59**R separated in the vehicle front-rear direction and on the left side in the vehicle width direction, a main fuel injection valve side fuel supply pipe **94** for supplying fuel to the the main fuel injection valves **66**F, **66**R is provided to extend in the vehicle front-rear direction.

The main fuel injection valve side fuel supply pipe **94** is connected to the main fuel injection valve side branched fuel hose **82** through a joint member **95**, and the joint member **95** is arranged to pass through the bracket **70** on the left side.

The joint member **95** is placed to pass through the perforated aperture **72** which, of the plurality of perforated apertures **72** provided in the connecting plate portion **70***a* of the bracket **70** on the left side, is at the forefront. The joint member **95** and the first boss portion **70***b* possessed by the bracket **70** are configured to overlap each other partly at least as viewed in a plan view.

The throttle valves **60**F, **60**R with which the throttle bodies **59**F, **59**R are provided respectively are driven by an actuator **97**, and a case **98** for the actuator **97** is fastened to a left part on the front bank side throttle body **59**F on the left side.

The actuator **97** has an electric motor **96** that generates a power to drivingly turn the throttle valves **60**F, **60**R. The electric motor **96** is placed to extend in the vehicle width direction ahead of the front bank side throttle bodies **59**F which, of the front bank side throttle bodies **59**F and the rear bank side throttle bodies **59**R separated in the vehicle front-rear direction, is on the front side, and is attached to the case **98** to be housed in the unpurified chamber **48**.

In operation, fuel is injected from the main fuel injection valves **66**F, **66**R into the intake passages **57**F, **57**R that establish the communication between the intake ports **44**F, **44**R provided in the cylinder heads **32**F, **32**R of the engine body **17** and the purified chamber **49** of the air cleaner **42**. Fuel is also injected from the secondary fuel injection valves **67**F, **67**R into the intake passages **57**F, **57**R on an upper side in stream relative to the main fuel injection valves **66**F, **66**R in the flow direction in the intake passages **57**F, **57**R. The secondary fuel injection valves **67**F, **67**R being one of the main fuel injection valves **66**F, **66**R and the secondary fuel injection valves **67**F, **67**R are housed in the purified chamber

49, while the main fuel injection valves 66F, 66R are housed in the unpurified chamber 48 of the air cleaner 42. The common fuel supply hose 80 for leading fuel from the fuel tank 30 to the main fuel injection valves 66F, 66R and the secondary fuel injection valves 67F, 67R in common is connected to the branching connection pipe 81 which is supported to pass through the cleaner case 45 of the air cleaner 42 and the bulkhead 50 and which is placed in one of the unpurified chamber 48 and the purified chamber 49. The branching connection pipe 81 is connected to the main fuel injection valve side branched fuel hose 82 for leading fuel toward the main fuel injection valves 66F, 66R side and the secondary fuel injection valve side branched fuel hose 83 for leading fuel toward the secondary fuel injection valves 67F, 67R side. Thus, the fuel piping can be simplified by containing in the air cleaner 42 the branching connection pipe 81 that distributes fuel to the main fuel injection valves 66F, 66R and the secondary fuel injection valves 67F, 67R. A decrease in the number of parts can be realized by making unnecessary fastening members or the like that secure the branching connection pipe 81 to the cleaner case 45. Furthermore, performing machining to form fastening portions on the cleaner case 45 and the branching connection pipe 81 becomes unnecessary, whereby the manpower and thus cost in machining can be decreased.

Further, the branching connection pipe 81 having the pair of branched pipe portions 81*b*, 81*c* is placed in the unpurified chamber 48, and one 81*b* of both of the branched pipe portions 81*b*, 81*c* passes through the bulkhead 50 and is supported by the bulkhead 50 to open on the purified chamber 49 side. Thus, it is unnecessary to perform machining for fuel piping connection at a part on the purified chamber 49 side of the cleaner case 45, and this contributes to securing the airtightness of the purified chamber 49.

Further, the cleaner case 45 is constructed by combining the lower case half body 46 and the upper case half body 47 which are dividable into upper and lower parts, and the branching connection pipe 81 which is placed in the unpurified chamber 48 defined between the bulkhead 50 and the lower case half body 46 passes through the lower case half body 46 and is connected to the common fuel supply hose 80. Thus, it is unnecessary to perform machining for fuel piping connection at a part on the purified chamber 49 side of the cleaner case 45, and this contributes to securing the airtightness of the purified chamber 49.

Further, the branched pipe portion 81*b* on one side possessed by the branching connection pipe 81 and opening on the purified chamber 49 side is connected by the quick connector 87 to the secondary fuel injection valve side branched fuel hose 83 being the branched fuel conduit that, of the main fuel injection valve side branched fuel hose 82 and the secondary fuel injection valve side branched fuel hose 83, is arranged in the purified chamber 49. Thus, at the time of assembling the air cleaner 42, a tool is not required in connecting the secondary fuel injection valve side branched fuel hose 83 placed in the purified chamber 49 to the branched pipe portion 81*b* opening on the purified chamber 49 side, so that the interior of the purified chamber 49 can be prevented from becoming dirty by using any such tool.

Further, since the grommets 88, 89 being annular elastic seal members are respectively interposed between the branched connection pipe 81, and the cleaner case 45 and the bulkhead 50, the sealing performance at the portions where the branching connection pipe 81 passes through can be ensured. Furthermore, pulsation in fuel pressure can be restrained from being transmitted from the branching connection pipe 81 to the cleaner case 45, so that the generation of vibration at the cleaner case 45 can be suppressed.

Further, at least some of intake passages 57F, 57R that make communication between the purified chamber 49 and the intake ports 44F, 44R are formed by the air funnels 58F, 58R opening to the purified chamber 49 and the throttle bodies 59F, 59R that are arranged in the unpurified chamber 48 and are connected to the downstream end parts of the air funnels 58F, 58R. Thus, a required capacity of the air cleaner 42 can be secured by arranging in the unpurified chamber 48 movable members such as the throttle valves 60F, 60R urged in the throttle bodies 59F, 59R. This contributes to downsizing the whole of the intake device extending from the air cleaner 42 to the cylinder heads 32F, 32R.

Further, the throttle bodies 59F, 59R separated in the vehicle front-rear direction are arranged in the unpurified chamber 48 with themselves mutually coupled by the brackets 70, 71 that are arranged on the lateral sides of the throttle bodies 59F, 59R. The joint member 95 that connects the main fuel injection valve side branched fuel hose 82 to the main fuel injection valve side fuel supply pipe 94 connected to the main fuel injection valves 66F, 66R annexed to the throttle bodies 59F, 59R is arranged to pass through the bracket 70. This makes it easy to perform the connection and separation between the main fuel injection valve side fuel supply pipe 94 and the main fuel injection valve side branched fuel hose 82 at the time of assembling and disassembling. This contributes to simplifying the fuel piping.

Further, the bracket 70 on the left side has the connecting plate portion 70*a* that is fastened to the throttle bodies 59F, 59R separated in the vehicle front-rear direction and arranged on the left side and that is provided with the perforated aperture 72 through which the joint member 95 passes. The first boss portion 70*b* is placed on the throttle bodies 59F, 59R side with respect to the connecting plate portion 70*a* and is consecutively connected to either one of the front and rear parts (the front part in this embodiment) of the connecting plate portion 70*a* and is fastened to the lower part of the cleaner case 45. The second boss portion 70*c* is placed on the opposite side to the throttle bodies 59F, 59R with respect to the connecting plate portion 70*a* and is consecutively connected to the other of the front and rear parts (the rear part in this embodiment) of the connecting plate portion 70*a* and is fastened to the cleaner case 45. The joint member 95 and the first boss portion 70*b* are arranged to overlap each other partly at least as viewed in the plan view. Thus, the region occupied by the first boss portion 70*b* and the region occupied by the joint member 95 are piled up vertically. This makes it possible to avoid an increase in dimension of the cleaner case 45 and at the same time, to secure the space required for performing the fastening operation of the first boss portion 70*b* to the cleaner case 45.

Further, the branching connection pipe 81 is placed at the position where, as viewed in the lateral direction, it overlaps some of the throttle bodies 59R on the rear side of the throttle bodies 59F, 59R separated in the vehicle front-rear direction. The electric motor 96 for generating the power to drivingly turn the throttle valves 60F, 60R respectively possessed by the throttle bodies 59F, 59R is housed in the unpurified chamber 48 to be located ahead of the throttle bodies 59F on the front side of the throttle bodies 59F, 59R separated in the vehicle front-rear direction. Thus, it can be avoided that the air cleaner 42 housing the fuel supply device increases in dimension.

Up to this point, the embodiment according to the present invention has been described, but the present invention is not limited to the aforementioned embodiment and various

changes in design can be made without departing from the invention as set forth in claims.

REFERENCE SIGNS LIST

17 . . . Engine body
30 . . . Fuel tank
32F, **32**R . . . Cylinder head
42 . . . Air cleaner
44F, **44**R . . . Intake port
45 . . . Cleaner case
46 . . . Lower case half body
47 . . . Upper case half body
48 . . . Unpurified chamber
49 . . . Purified chamber
50 . . . Bulkhead
57F, **57**R . . . Intake passage
58F, **58**R . . . Air funnel
59F, **59**R . . . Throttle body
60F, **60**R . . . Throttle valve
61 . . . Cleaner element
66F, **66**R . . . Main fuel injection valve
67F, **67**R . . . Secondary fuel injection valve
70 . . . Bracket
70*a* . . . Connecting plate portion
70*b* . . . First boss portion
70*c* . . . Second boss portion
72 . . . Perforated aperture
80 . . . Common fuel supply hose as common fuel supply conduit
81 . . . Branching connection pipe
81*b*, **81***c* . . . Branched pipe portion
82 . . . Main fuel injection valve side branched fuel hose as main fuel injection valve side branched fuel conduit
83 . . . Secondary fuel injection valve side branched fuel hose as secondary fuel injection valve side branched fuel conduit
87 . . . Quick connector
88, **89** . . . Grommet being elastic seal member
94 . . . Main fuel injection valve side fuel supply pipe
95 . . . Joint member
96 . . . Electric motor
E . . . Engine

The invention claimed is:

1. A fuel supply structure in a vehicle engine, said fuel supply structure comprising:

an air cleaner configured to be divided in a cleaner case by a bulkhead, said bulkhead holding a cleaner element in an unpurified chamber and a purified chamber;

a main fuel injection valve configured to inject fuel into an intake passage that enables communication between an intake port provided in a cylinder head of an engine body and the purified chamber; and

a secondary fuel injection valve configured to inject fuel into the intake passage on an upper side relative to the main fuel injection valve in a flow direction in the intake passage,

wherein one of the main fuel injection valve and the secondary fuel injection valve is housed in the purified chamber, wherein another of the main fuel injection valve and the secondary fuel injection valve is housed in the unpurified chamber, wherein a common fuel supply conduit configured to lead fuel from a fuel tank to the main fuel injection valve and the secondary fuel injection valve in common is connected to a branching connection pipe which is supported to pass through the cleaner case and the bulkhead and which is disposed in one of the unpurified chamber and the purified chamber, and wherein the branching connection pipe is connected to a main fuel injection valve side branched fuel conduit configured to lead fuel toward the main fuel injection valve side and to a secondary fuel injection valve side branched fuel conduit for leading fuel toward the secondary fuel injection valve side.

2. The fuel supply structure in a vehicle engine according to claim **1**, wherein the branching connection pipe includes a pair of branched pipe portions disposed in the unpurified chamber, and wherein one of the branched pipe portions passes through the bulkhead and is supported by the bulkhead to open on a purified chamber side.

3. The fuel supply structure in a vehicle engine according to claim **2**, wherein a lower case half body and an upper case half body, being dividable vertically, are combined to constitute the cleaner case, and wherein the branching connection pipe which is disposed in the unpurified chamber defined between the bulkhead and the lower case half body passes through the lower case half body and is connected to the common fuel supply conduit.

4. The fuel supply structure in a vehicle engine according to claim **2**, wherein the branched pipe portion on one side possessed by the branching connection pipe and opening on the purified chamber side is connected by a quick connector to the branched fuel conduit which, of the main fuel injection valve side branched fuel conduit and the secondary fuel injection valve side branched fuel conduit, is disposed in the purified chamber.

5. The fuel supply structure in a vehicle engine according to claim **2**, wherein annular elastic seal members are respectively interposed between the branching connection pipe, and the cleaner case and the bulkhead.

6. The fuel supply structure in a vehicle engine according to claim **1**, wherein at least a part of the intake passage making communication between the purified chamber and the intake port comprises an air funnel opening to the purified chamber and a throttle body disposed in the unpurified chamber and connected to a downstream end part of the air funnel.

7. The fuel supply structure in a vehicle engine according to claim **6**, wherein at least two throttle bodies are separated in the vehicle front-rear direction and are disposed in the unpurified chamber, and are mutually coupled by a bracket disposed on a lateral side of the at least two throttle bodies, and wherein a joint member connecting the main fuel injection valve side branched fuel conduit to a main fuel injection valve side fuel supply pipe which is connected to the main fuel injection valves respectively annexed to the throttle bodies is disposed to pass through the bracket.

8. The fuel supply structure in a vehicle engine according to claim **7**, wherein the bracket includes a connecting plate portion which is fastened to the at least two throttle bodies separated in the vehicle front-rear direction and which is provided with a perforated aperture making the joint member pass therethrough, a first boss portion which is disposed on the throttle bodies side with respect to the connecting plate portion and which is consecutively connected to either one of front and rear parts of the connecting plate portion to be fastened to a lower part of the cleaner case, and a second boss portion which is disposed on an opposite side to the throttle bodies with respect to the connecting plate portion and which is consecutively connected to the other of the front and rear parts of the connecting plate portion to be fastened to the cleaner case and wherein the joint member and the first boss portion are disposed to at least partially overlap as viewed in a plan view.

9. The fuel supply structure in a vehicle engine according to claim 6, wherein the branching connection pipe is disposed at a position where, as viewed laterally, it overlaps a part of the throttle body on a rear side of the throttle bodies separated in the vehicle front-rear direction, and wherein an electric motor configured to generate a power to drivingly turn throttle valves respectively provided in the throttle bodies is housed in the unpurified chamber to be placed ahead of the throttle body on a front side of the at least two throttle bodies separated in the vehicle front-rear direction.

10. A fuel supply structure in a vehicle engine, said fuel supply structure comprising:

air cleaner means for cleaning air, said air cleaner means being divided in a cleaner case means by a bulkhead, said bulkhead holding cleaner element means in an unpurified chamber and a purified chamber;

main fuel injecting means for injecting fuel into an intake passage that enables communication between an intake port in a cylinder head of an engine body and the purified chamber;

secondary fuel injection means for injecting fuel into the intake passage on an upper side relative to the main fuel injection means in a flow direction in the intake passage,

wherein one of the main fuel injection means and the secondary fuel injection means is housed in the purified chamber, wherein another of the main fuel injection means and the secondary fuel injection means is housed in the unpurified chamber, wherein a common fuel supply means for leading fuel from a fuel tank to the main fuel injection means and the secondary fuel injection means in common is connected to a branching connection pipe means which is supported to pass through the cleaner case means and the bulkhead and which is disposed in one of the unpurified chamber and the purified chamber, and wherein the branching connection pipe means is connected to a main fuel injection means side branched fuel conduit means for leading fuel toward the main fuel injection means side and to a secondary fuel injection means side branched fuel conduit means for leading fuel toward the secondary fuel injection means.

11. The fuel supply structure in a vehicle engine according to claim 10, wherein the branching connection pipe means includes a pair of branched pipe portions disposed in the unpurified chamber, and wherein one of the branched pipe portions passes through the bulkhead and is supported by the bulkhead to open on a purified chamber side.

12. The fuel supply structure in a vehicle engine according to claim 11, wherein a lower case half body means and an upper case half body means are vertically dividable and are combined to form the cleaner case means, and wherein the branching connection pipe means which is disposed in the unpurified chamber defined between the bulkhead and the lower case half body means passes through the lower case half body means and is connected to the common fuel supply means.

13. The fuel supply structure in a vehicle engine according to claim 11, wherein the branched pipe portion means on one side possessed by the branching connection pipe means and opening on the purified chamber side is connected by quick connector means to the branched fuel conduit means which, of the main fuel injection means side branched fuel conduit means and the secondary fuel injection valve side branched fuel conduit means is disposed in the purified chamber.

14. The fuel supply structure in a vehicle engine according to claim 11, further comprising annular elastic seal means for sealing, said annular elastic seal means being interposed between the branching connection pipe means, the cleaner case means, and the bulkhead.

15. The fuel supply structure in a vehicle engine according to claim 10, wherein at least a part of the intake passage making communication between the purified chamber and the intake port comprises air funnel means for funneling air, said air funnel means opening to the purified chamber, and throttle body means for throttling, said throttle body means being disposed in the unpurified chamber and connected to a downstream end part of the air funnel means.

16. The fuel supply structure in a vehicle engine according to claim 15, further comprising at least two throttle body means being separated in the vehicle front-rear direction, said at least two throttle body means being disposed in the unpurified chamber, and are mutually coupled by a bracket disposed on a lateral side of the at least two throttle body means,

wherein a joint member connected the main fuel injection means side branched fuel conduit means to a main fuel injection means side fuel supply pipe connected to the main fuel injection means respectively annexed to the at least two throttle body means is disposed to pass through the bracket.

17. The fuel supply structure in a vehicle engine according to claim 16, wherein the bracket includes a connecting plate portion which is fastened to the at least two throttle body means separated in the vehicle front-rear direction, and is provided with a perforated aperture making the joint member pass therethrough, wherein a first boss portion is disposed on the at least two throttle body means side with respect to the connecting plate portion, and being consecutively connected to either one of front and rear parts of the connecting plate portion to be fastened to a lower part of the cleaner case means, and wherein a second boss portion is disposed on an opposite side to the at least two throttle body means with respect to the connecting plate portion and which is consecutively connected to the other of the front and rear parts of the connecting plate portion to be fastened to the cleaner case, and wherein the joint member and the first boss portion are disposed to at least partially overlap as viewed in a plan view.

18. The fuel supply structure in a vehicle engine according to claim 15, wherein the branching connection pipe means is disposed at a position where, as viewed laterally, it overlaps a part of the throttle body means on a rear side of the at least two throttle body means separated in the vehicle front-rear direction, and wherein electric motor means for generating power to drivingly turn throttle valves respectively provided in the at least two throttle body means is housed in the unpurified chamber to be placed ahead of the throttle body means on a front side of the at least two throttle body means separated in the vehicle front-rear direction.

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